Temperature Scales and Thermal Expansion – Worksheet 2 (Volumetric)

1. A 2.00 L aluminum container at 35.0°C heats up to 100.0°C. What is the change in volume the container experiences?

$\Delta V = ?$
$V_0 = 2.00\,L$
$T_i = 35.0\,^\circ C$
$T_f = 100.0\,^\circ C$
$\beta = 0.75 \times 10^{-4}\,^\circ C^{-1}$

$\Delta V = \beta V_0 \Delta T$
$\Delta V = 0.75 \times 10^{-4}\,^\circ C^{-1}(2.00\,L)(100.0\,^\circ C - 35.0\,^\circ C)$
$\Delta V \approx 9.8 \times 10^{-3}\,L$

2. How much does the volume of a 5.0 L copper jug change if it experiences a temperature change of 50.0 °C?

$\Delta V = ?$
$V_0 = 5.0\,L$
$\beta = 0.50 \times 10^{-4}\,^\circ C^{-1}$
$\Delta T = 50.0\,^\circ C$

$\Delta V = \beta V_0 \Delta T$
$\Delta V = 0.50 \times 10^{-4}\,^\circ C^{-1}(5.0\,L)(50.0\,^\circ C)$
$\Delta V \approx 0.013\,L$

3. 1.5000 L of antifreeze at 50.000°C cools to -26.000°C. What is the final volume? use 5 sig figs.

$V_0 = 1.5000\,L$
$T_i = 50.000\,^\circ C$
$T_f = -26.000\,^\circ C$
$V_f = ?$
$\beta = 1.08 \times 10^{-4}\,^\circ C^{-1}$

$\Delta V = \beta V_0 \Delta T$
$V_f - V_0 = \beta V_0 \Delta T$
$V_f = \beta V_0 \Delta T + V_0$

$V_f = 1.08 \times 10^{-4}\,^\circ C^{-1}(1.5000\,L)(-26.000\,^\circ C - 50.000\,^\circ C) + 1.5000\,L$
$V_f \approx 1.4877\,L$

4. How much water will spill from a 5.00 L copper vat if the temperature is increased by 35.0°C?

☐ Water

$V_0 = 5.00\,L$
$\Delta V_w = ?$
$\Delta T = 35.0\,^\circ C$
$\beta_w = 2.1 \times 10^{-4}\,^\circ C^{-1}$

$\Delta V_w = \beta_w V_0 \Delta T$

Copper

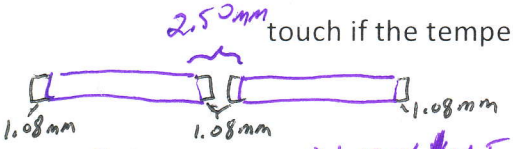
$V_0 = 5.00\,L$
$\Delta V_c = ?$
$\Delta T = 35.0\,^\circ C$
$\beta_c = 0.50 \times 10^{-4}\,^\circ C^{-1}$

$\Delta V_c = \beta_c V_0 \Delta T$

Spillage

$\Delta V_w - \Delta V_c$
$\beta_w V_0 \Delta T - \beta_c V_0 \Delta T$
$V_0 \Delta T (\beta_w - \beta_c)$
$5.00\,L(35.0\,^\circ C)(2.1 \times 10^{-4}\,^\circ C^{-1} - 0.50 \times 10^{-4}\,^\circ C^{-1})$
$0.0280\,L$

5. If two steel rods are placed 2.50 mm apart when the temperature is -30.0 °C, will they touch if the temperature is increased to 30.0°C if both rods are originally 3.00 m?



$L_0 = 3.00\,m$
$T_i = -30.0\,^\circ C$
$T_f = 30.0\,^\circ C$
$\alpha = 12 \times 10^{-6}\,^\circ C^{-1}$
$\Delta L = ?$

$\Delta L = \alpha L_0 \Delta T$
$\Delta L = 12 \times 10^{-6}\,^\circ C^{-1}(3.00\,m)(30\,^\circ C - (-30\,^\circ C))$
$\Delta L = 0.00216\,m$
$\Delta L = 2.16\,mm$

Expand 2.16mm over entire length
$\therefore \frac{2.16\,mm}{2}$ each end
$= 1.08\,m$ each end

The Bars do not touch!

Volumetric Expansion
Key Pg 2 of 2

6. A beaker is filled to the brim with 250 mL of ethyl alcohol at 15°C. How much will overflow at 30.0°C? (Assume that the beaker does not expand significantly.)

$\Delta V = ?$
$V_0 = 250 mL$
$T_i = 15°C$
$T_f = 30.0°C$
$\beta = 11.2 \times 10^{-4} °C^{-1}$

$\Delta V = \beta V_0 \Delta T$
$\Delta V = 11.2 \times 10^{-4} °C^{-1} (250 mL)(30.0°C - 15°C)$
$\Delta V = 4.2 mL$

7. How much would the volume of 4.00 L of gasoline change if the temperature increased from – 40.0°C to 318 K?

$\Delta V = ?$
$V_0 = 4.00 L$
$T_i = -40.0°C = 233 K$
$T_f = 318 K$
$\beta = 4.9 \times 10^{-4} °C^{-1}$

$\Delta V = \beta V_0 \Delta T$
$\Delta V = 4.9 \times 10^{-4} °C^{-1} (4.00 L)(318 K - 233 K)$
$\Delta V \approx 0.17 L$

8. How much water will spill from a 5.00 L vat if the temperature increased by 35.0°C?

$V_0 = 5.00 L$
$\Delta V_0 = ?$
$\Delta T = 35.0°C$
$\beta = 2.1 \times 10^{-4} °C^{-1}$

$\Delta V = \beta V_0 \Delta T$
$\Delta V = 2.1 \times 10^{-4} °C^{-1} (5.00 L)(35.0°C)$
$\Delta V = 0.037 L$

9. A concrete (36×10^{-6} °C^{-1}) sidewalk section 8.000 m by 1.000m by 0.100 m at exactly 0°C will expand to what volume at 35°C?

$V_f = ?$
$V_0 = (8.000m)(1.000m)(0.100m) = 0.800 m^3$
$T_i = 0°C$
$T_f = 35°C$
$\beta = 36 \times 10^{-6} °C^{-1}$

$\Delta V = \beta V_0 \Delta T$
$\Delta V_f - V_i = \beta V_0 \Delta T$
$V_f = \beta V_0 \Delta T + V_i$
$V_f = 36 \times 10^{-6} °C^{-1} (0.800 m^3)(35°C - 0°) + 0.800 m^3$
$V_f = 0.801008 m^3$

$V_f \approx 0.8010 m^3$

10. An air-filled balloon of 15.0 cm radius at 11°C is heated to 121°C. What change in volume occurs?

$\Delta V = ?$
$V_0 = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi (15.0cm)^3$
$V_0 = 14137 cm^3$
$T_i = 11°C$
$T_f = 121°C$
$\beta = 34 \times 10^{-4} °C^{-1}$

$\Delta V = \beta V_0 \Delta T$
$\Delta V = 34 \times 10^{-4} °C^{-1} (14137 cm^3)(121°C - 11°C)$
$\Delta V \approx 5.3 \times 10^3 m^3$